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Abe et al.

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(54) **VEHICLE CONTROL UNIT**

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(Continued)

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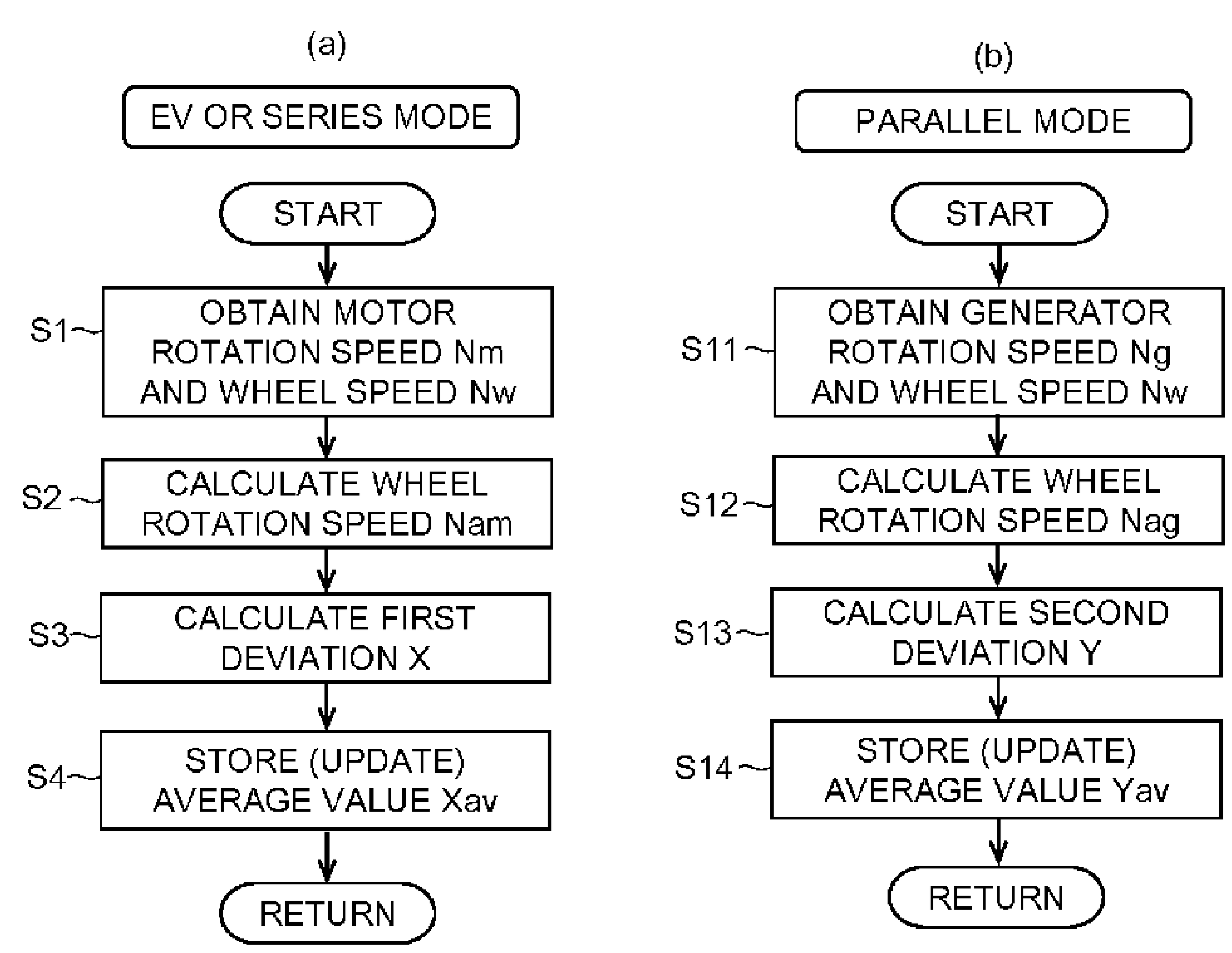
(57) **ABSTRACT**

A vehicle includes connecting/disconnecting mechanisms (**20**,**30**) disposed on power transmission paths between first rotating electric machines (**3**,**4**) mounted on the vehicle and an output shaft (**12**) that drives a wheel, a first rotating electric machine speed sensor (**43**,**44**) that detects a rotation speed of the first rotating electric machine (**3**,**4**) as a first rotation speed (Nm,Ng), and a wheel speed sensor (**42**) that detects a rotation speed of the wheel as a wheel speed (Nw). A control unit (**5**) includes: a first calculator (**5**B) that calculates an axle rotation speed (Nam,Nag) representing a rotation speed of the output shaft (**12**) based on the first rotation speed (Nm,Ng) in a state where the first connecting/disconnecting mechanism (**20**,**30**) is engaged; a monitoring
(Continued)



unit (**5**C) that calculates a deviation (X,Y) between the axle rotation speed (Nam,Nag) calculated by the first calculator (**5**B) and the wheel speed (Nw); and a second calculator (**5**D) that calculates the axle rotation speed (Nax,Nay) by calibrating the wheel speed (Nw) based on the calculated deviation (X,Y) in a state where the first connecting/disconnecting mechanism (**20**,**30**) is disengaged.

16 Claims, 5 Drawing Sheets

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B60W 10/11	(2012.01)
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(58) **Field of Classification Search**
CPC B60K 6/442; B60K 6/52; B60K 6/547; B60K 17/02; B60K 17/356
See application file for complete search history.

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FIG. 1

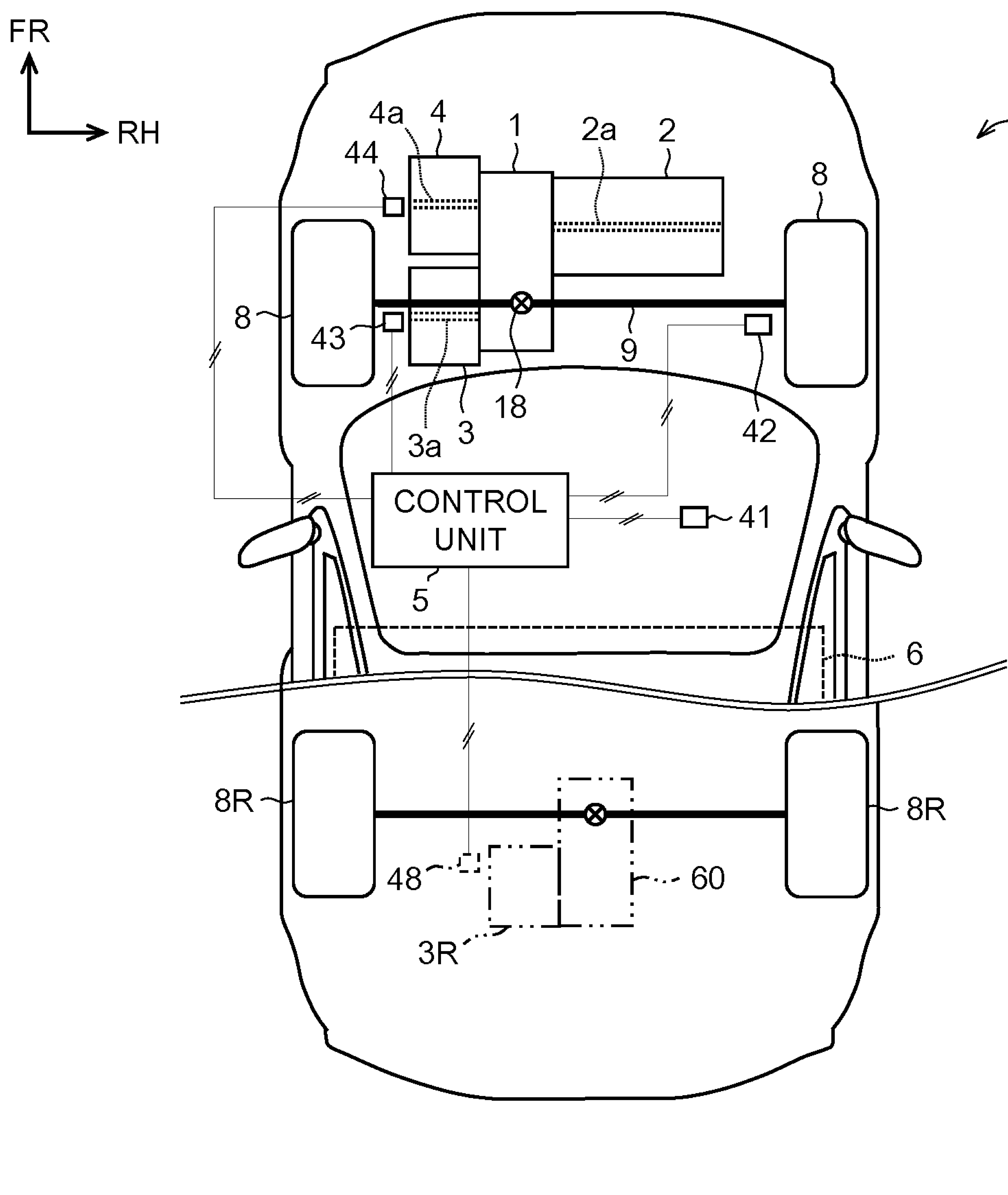

FR
RH
10
4a
4
1
2a
2
44
8
8
43
9
18
42
3a
3
CONTROL UNIT
41
5
6
8R
8R
48
60
3R

FIG. 2

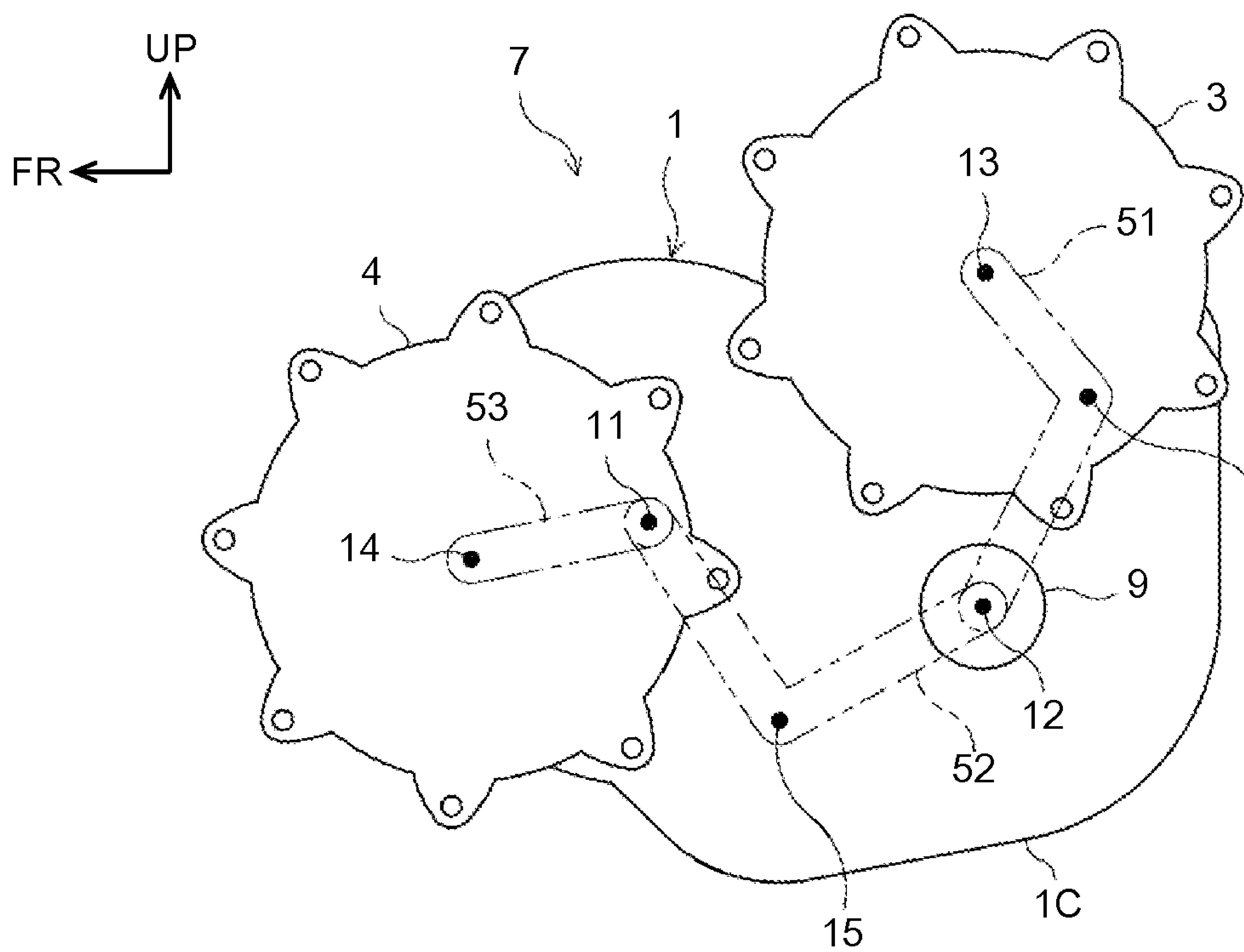


FIG. 3

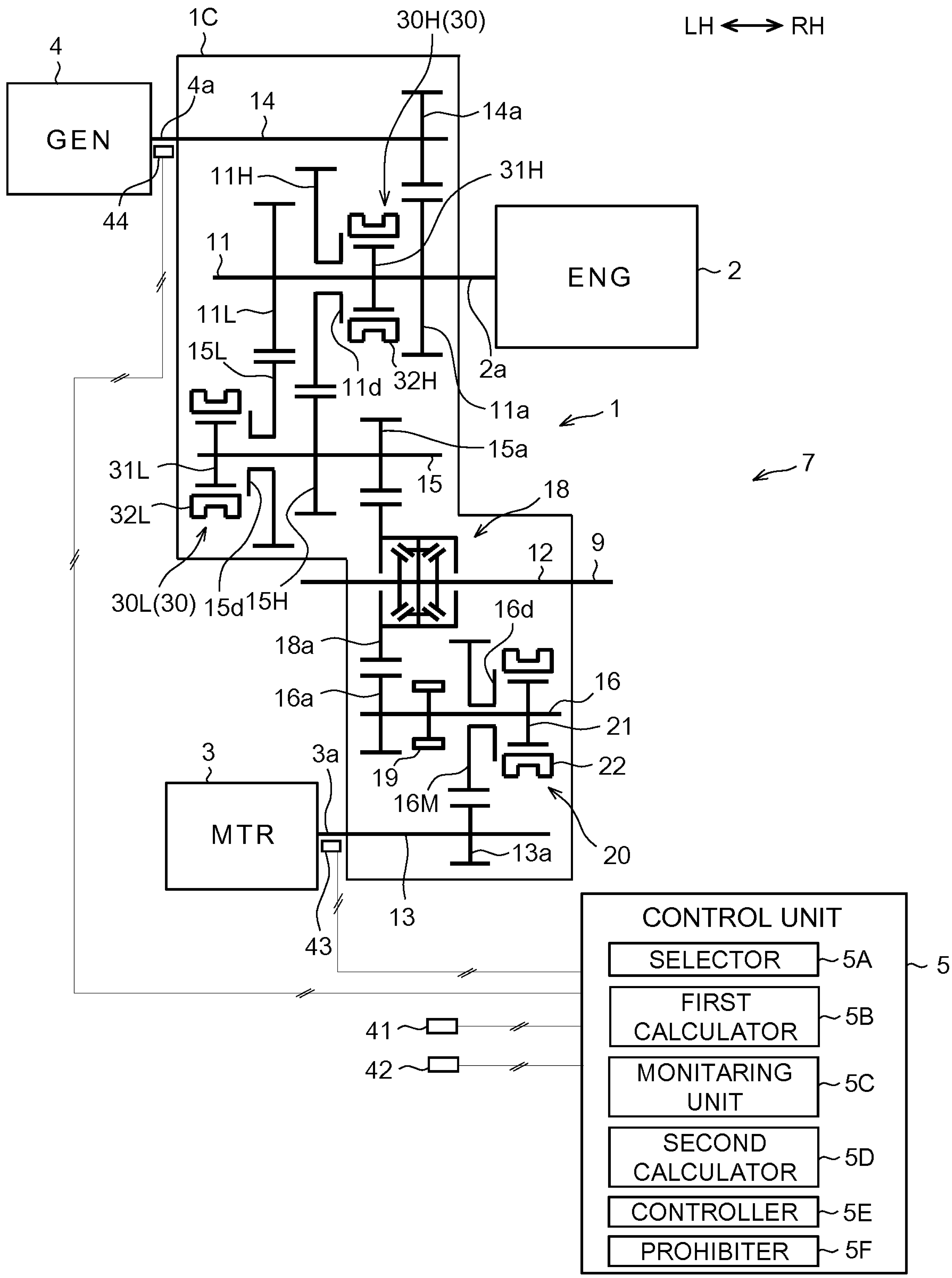

1C
30H(30)
LH
RH
4
GEN
4a
14
14a
11H
31H
44
11
ENG
2
11L
15L
11d
32H
2a
11a
1
15a
7
31L
15
18
32L
12
9
30L(30)
15d
15H
16d
18a
16
16a
21
19
22
3
3a
16M
MTR
13a
20
13
43
CONTROL UNIT
SELECTOR
5A
5
FIRST CALCULATOR
5B
41
42
MONITARING UNIT
5C
SECOND CALCULATOR
5D
CONTROLLER
5E
PROHIBITER
5F

FIG. 4

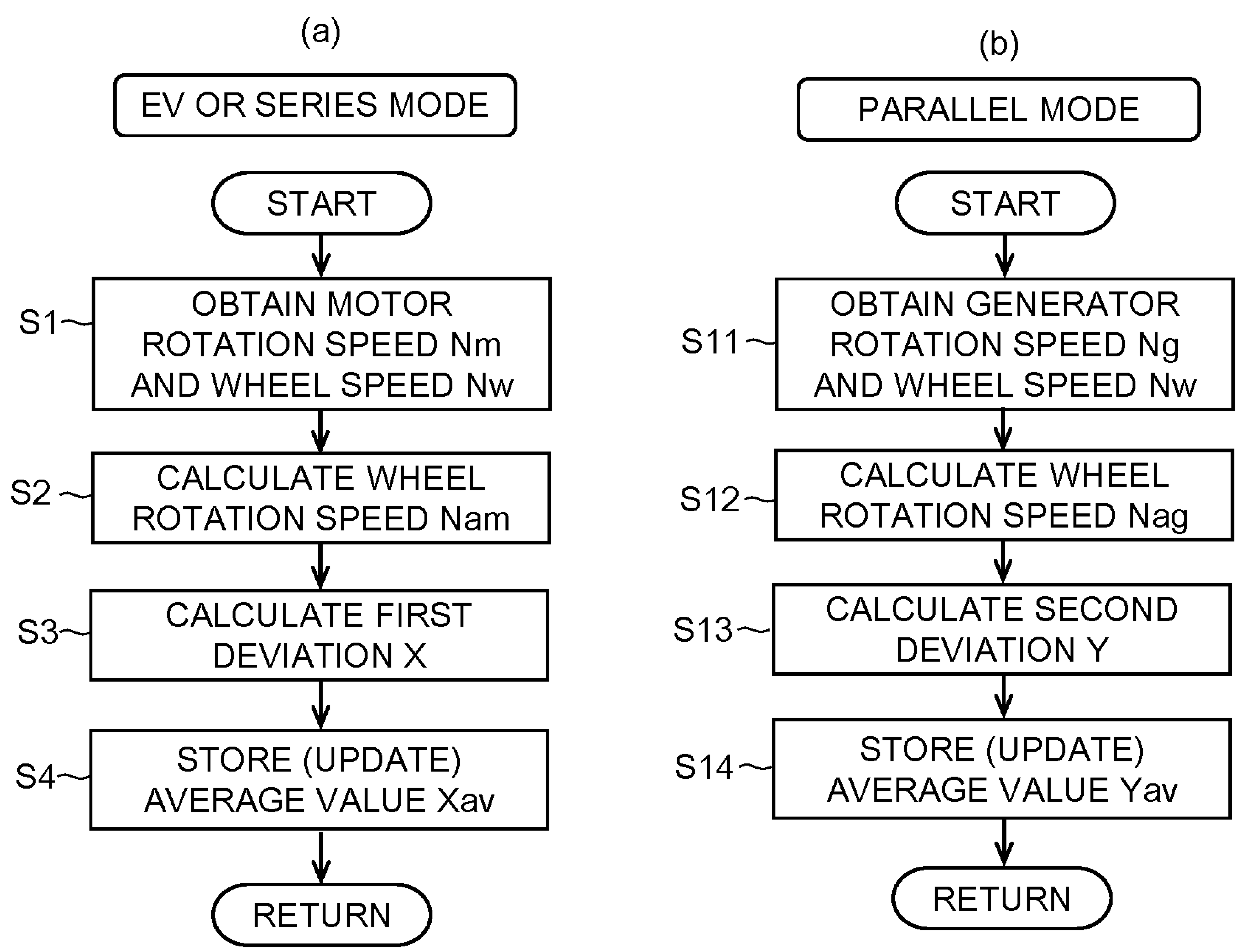
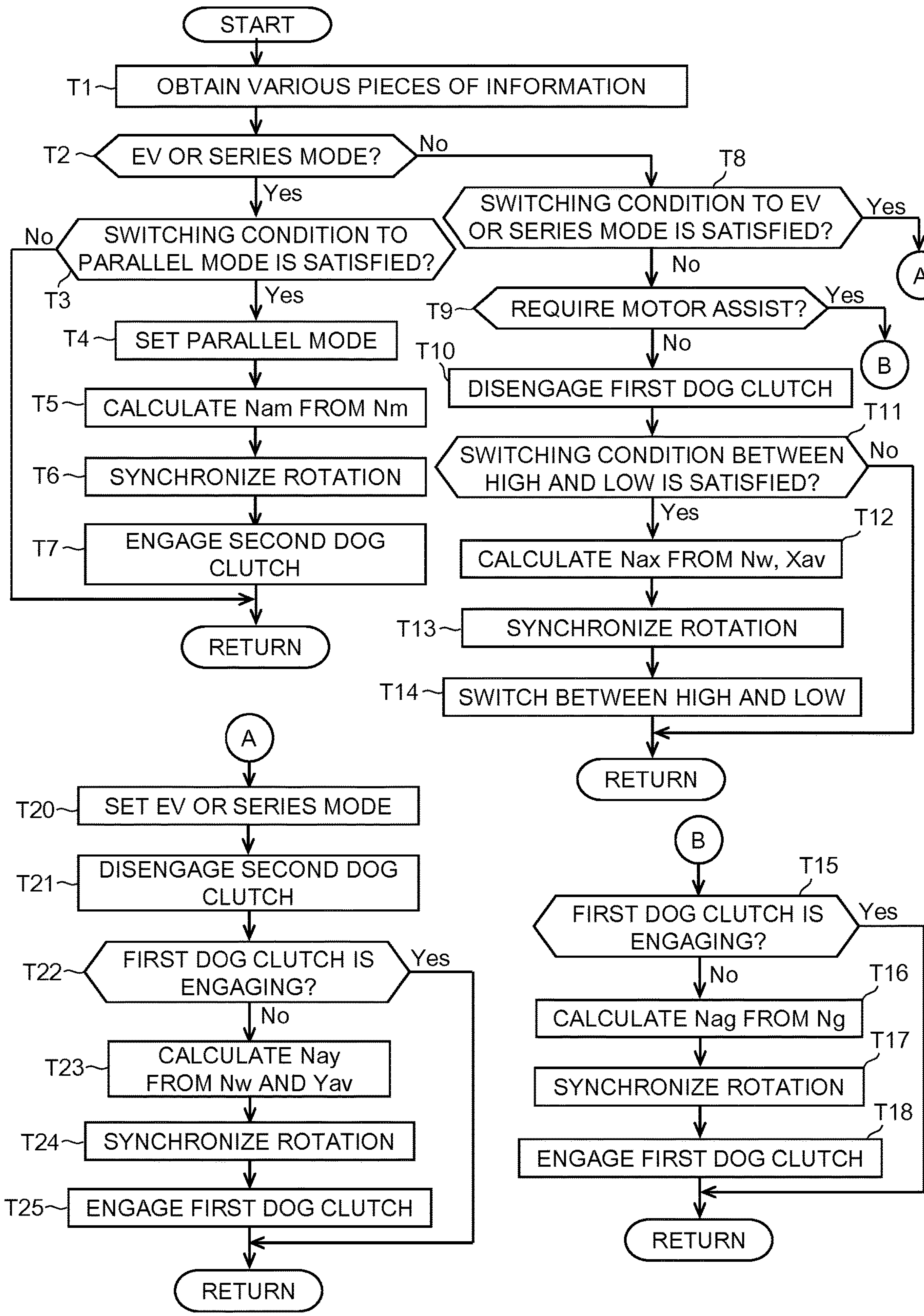

(a)
EV OR SERIES MODE
START
S1
OBTAIN MOTOR ROTATION SPEED Nm AND WHEEL SPEED Nw
S2
CALCULATE WHEEL ROTATION SPEED Nam
S3
CALCULATE FIRST DEVIATION X
S4
STORE (UPDATE) AVERAGE VALUE Xav
RETURN
(b)
PARALLEL MODE
START
S11
OBTAIN GENERATOR ROTATION SPEED Ng AND WHEEL SPEED Nw
S12
CALCULATE WHEEL ROTATION SPEED Nag
S13
CALCULATE SECOND DEVIATION Y
S14
STORE (UPDATE) AVERAGE VALUE Yav
RETURN

FIG. 5


START
T1
OBTAIN VARIOUS PIECES OF INFORMATION
T2
EV OR SERIES MODE?
No
Yes
T8
SWITCHING CONDITION TO EV OR SERIES MODE IS SATISFIED?
Yes
A
No
SWITCHING CONDITION TO PARALLEL MODE IS SATISFIED?
T3
Yes
T9
REQUIRE MOTOR ASSIST?
Yes
B
T4
SET PARALLEL MODE
No
T10
DISENGAGE FIRST DOG CLUTCH
T5
CALCULATE Nam FROM Nm
T11
SWITCHING CONDITION BETWEEN HIGH AND LOW IS SATISFIED?
No
T6
SYNCHRONIZE ROTATION
Yes
T12
CALCULATE Nax FROM Nw, Xav
T7
ENGAGE SECOND DOG CLUTCH
RETURN
T13
SYNCHRONIZE ROTATION
T14
SWITCH BETWEEN HIGH AND LOW
RETURN
A
T20
SET EV OR SERIES MODE
T21
DISENGAGE SECOND DOG CLUTCH
T22
FIRST DOG CLUTCH IS ENGAGING?
Yes
No
T23
CALCULATE Nay FROM Nw AND Yav
T24
SYNCHRONIZE ROTATION
T25
ENGAGE FIRST DOG CLUTCH
RETURN
B
T15
FIRST DOG CLUTCH IS ENGAGING?
Yes
No
T16
CALCULATE Nag FROM Ng
T17
SYNCHRONIZE ROTATION
T18
ENGAGE FIRST DOG CLUTCH
RETURN

VEHICLE CONTROL UNIT

TECHNICAL FIELD

The present disclosure relates to a control unit of a vehicle having a connecting/disconnecting mechanism provided on a power transmission path between a rotating electric machine and an output shaft.

BACKGROUND ART

Conventionally, in a vehicle having multiple driving sources (e.g., engine, motor, motor generator), clutches (connecting/disconnecting mechanisms) are interposed on the power transmission paths between the driving source and the output shaft, the engaging-disengaging state of the clutch by being controlled, switching of the driving source is performed. When a clutch is to be engaged, synchronization of the rotation is achieved so that the difference between the rotation speed of the driving source side and that of the output shaft side is equal to or less than a predetermined value (e.g., see Patent Document 1).

PRIOR ART DOCUMENTS

Patent Literature

[Patent Document 1] Japanese Laid-open Patent Publication No. 2017-5914

SUMMARY

Detailed Description

Problems to be Solved by the Disclosure

In order to synchronize the rotation for clutch engagement, the driving source is controlled such that the rotation speed of the driving source side matches the rotation speed (hereinafter referred to as "axle rotation speed") of the output shaft side. Generally, the driving source is provided with a high-precision rotation speed sensor for precisely controlling the operating state of the driving source. However, since the axle rotation speed is detected by a wheel speed sensor having a lower detection precision than the rotation speed sensor provided in the driving source, there is a problem that it is difficult to accurately rotate synchronize rotation during clutch engagement.

Means to Solve Problem

(1) A control unit disclosed herein for controlling a vehicle, the vehicle including a first connecting/disconnecting mechanism disposed on a first power transmission path between a first rotating electric machine mounted on the vehicle and an output shaft that drives a wheel, a first rotating electric machine speed sensor that detects a rotation speed of the first rotating electric machine as a first rotation speed, and a wheel speed sensor that detects a rotation speed of the wheel as a wheel speed, the control unit including: a first calculator that calculates an axle rotation speed representing a rotation speed of the output shaft based on the first rotation speed in a state where the first connecting/disconnecting mechanism is engaged; a monitoring unit that calculates a deviation between the axle rotation speed calculated by the first calculator and the wheel speed; and a second calculator that calculates the axle rotation speed by calibrating the wheel speed based on the calculated deviation in a state where the first connecting/disconnecting mechanism is disengaged.

(2) Preferably, the monitoring unit periodically calculates the deviation while the vehicle is running and stores an average value of a plurality of the deviations periodically calculated.

(3) Preferably, the vehicle further includes a second rotating electric machine mounted on a second power transmission path connected to the output shaft and a second connecting/disconnecting mechanism disposed on the second power transmission path. In this case, it is preferable the control unit further includes a controller that controls respective engaging-disengaging states of the first connecting/disconnecting mechanism and the second connecting/disconnecting mechanism; and the controller uses the axle rotation speed calculated by the second calculator to synchronize rotation of the second connecting/disconnecting mechanism to engage the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is disengaged.

(4) The first power transmission path and the second power transmission path are preferably configured such that a number of transmission stages from the output shaft to the first rotating electric machine is less than a number of transmission stages from the output shaft to the second rotating electric machine.

(5) It is preferable that the vehicle further includes an engine that is mounted on the vehicle and that causes the second rotating electric machine to generate electric power, and power of the engine is transmitted to the output shaft through the second power transmission path; and the second connecting/disconnecting mechanism has a function of engaging and disengaging the power through the second power transmission path and a function of switching between a high-gear stage and a low-gear stage.

(6) Preferably, the controller uses the axle rotation speed calculated by the first calculator to synchronize rotation of the second connecting/disconnecting mechanism to engage the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is engaged.

(7) Preferably, the vehicle further includes a second rotating electric machine speed sensor that detects a rotation speed of the second rotating electric machine as a second rotation speed. In this case, it is preferable that, in engaging the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is disengaged, the controller engages the second connecting/disconnecting mechanism after controlling, based on the axle rotation speed calculated by the second calculator and the second rotation speed detected by the second rotating electric machine speed sensor, the second rotating electric machine such that rotation of the second connecting/disconnecting mechanism synchronizes.

(8) Preferably, the control unit further includes a sub-controller that controls an engaging-disengaging state of the first connecting/disconnecting mechanism. In this case, it is preferable that, in engaging the first connecting/disconnecting mechanism in a state of being disengaged, the sub-controller engages the first connecting/disconnecting mechanism after controlling, based on the axle rotation speed calculated by the second calculator and the first rotation speed detected by the first rotating electric machine speed sensor, the first rotating electric machine such that rotation of the first connecting/disconnecting mechanism synchronizes.

(9) Preferably, the vehicle further includes a second rotating electric machine speed sensor that detects a rotation speed of the second rotating electric machine as a second rotation speed. In this case, it is preferable that each of the first connecting/disconnecting mechanism and the second connecting/disconnecting mechanism is a dog clutch; the first calculator calculates the axle rotation speed based on the second rotation speed in a state where the second connecting/disconnecting mechanism on the second power transmission path is engaged; the monitoring unit calculates a second deviation representing a deviation between the axle rotation speed calculated based on the second rotation speed and the wheel speed; the second calculator calculates the axle rotation speed using the wheel speed and the second deviation in the state where the second connecting/disconnecting mechanism on the second power transmission path is disengaged; and the controller uses the axle rotation speed calculated from the wheel speed and the second deviation to synchronize rotation of the first connecting/disconnecting mechanism to engage the first connecting/disconnecting mechanism in a state where the second connecting/disconnecting mechanism on the second power transmission path is disengaged.

(10) The control unit preferably includes a prohibitor that prohibits, when the deviation is a predetermined value or more, the first connecting/disconnecting mechanism from being disengaged.

(11) Preferably, the vehicle includes the first rotating electric machine that drives one of a front wheel and a rear wheel, a third rotating electric machine that drives the other one of the front wheel and the rear wheel without being interposed by a connecting/disconnecting mechanism, and a third rotating electric machine speed sensor that detects a rotation speed of the third rotating electric machine as a third rotation speed. In this case, it is preferable that when the wheel speed sensor has a failure, the second calculator calculates, based on the third rotation speed, a rotation speed of an axle connected to the one wheel.

Effect of the Disclosure

According to the control unit disclosed herein, the axle rotation speed can be precisely calculated.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention and wherein:

FIG. **1** is a top view illustrating an internal structure of a vehicle mounted with a control unit according to an embodiment;

FIG. **2** is a schematic side view showing a powertrain including a transaxle mounted on the vehicle of FIG. **1**;

FIG. **3** is a skeleton diagram showing a powertrain including the transaxle of FIG. **2**;

FIG. **4** is a flowchart example implemented in the monitoring unit of the control unit of FIG. **1**, FIG. **4**(*a*) being selected in an EV mode or series mode, and FIG. **4**(*b*) being selected in a parallel mode; and

FIG. **5** is a flowchart example for explaining the content of control performed by the control unit of FIG. **1**.

EMBODIMENT TO CARRY OUT THE DISCLOSURE

Description will now be made in relation to a vehicle control unit according to an embodiment with reference to the accompanying drawings. The following embodiment is merely illustrative and is not intended to exclude the application of various modifications and techniques not explicitly described in the embodiment. Each configuration of the present embodiment can be variously modified and implemented without departing from the scope thereof. Also, the configuration can be selected or omitted according to the requirement or appropriately combined.

[1. Overall Configuration]

A control unit **5** of the present embodiment is applied to a vehicle **10** shown in FIG. **1**, and controls a transaxle **1** mounted on the vehicle **10**. The vehicle **10** is a FF-type hybrid vehicle equipped with an engine **2** as a driving source and a motor **3** (electric motor, a first rotating electric machine) for running, and a generator **4** (a second rotating electric machine) for power generation. The generator **4** is coupled to the engine **2** and is operable independently of the operating state of the motor **3**. In addition, three of running modes of an EV mode, a series mode, and a parallel mode are prepared for the vehicle **10**. These running modes, by the control unit **5**, are alternatively selected according to the vehicle state and the running state, and a required output of the driver, and the engine **2**, the motor **3**, and the generator **4** are individually used depending on the selected mode.

The EV mode is a running mode in which the vehicle **10** is driven only on the motor **3** using the charged power of a driving-purpose battery **6**, stopping the engine **2** and the generator **4**. The EV mode is selected when a driving load and a vehicle speed are low or the charging level of the battery **6** is high. The series mode is a running mode in which the generator **4** is driven by the engine **2** to generate electric power and also the vehicle **10** is driven by the motor **3** using the generated electric power. The series mode is selected when a running load and a vehicle speed are moderate, or the charging level of the battery **6** is low. The parallel mode is a running mode in which the vehicle **10** is driven mainly by the power of the engine **2** and the driving of the vehicle **10** is assisted by the motor **3** if necessary, and is selected when a running load and a vehicle speed are high.

The diving wheels **8** (wheels, front wheels in this embodiment), the engine **2** and the motor **3** are connected in parallel through the transaxle **1**, and the respective power of the engine **2** and the motor **3** are individually transmitted from different power transmission paths. This means that each of the engine **2** and the motor **3** is a driving source that drives the output shaft **12** of the vehicle **10**. Further, to the engine **2**, the generator **4** and the driving wheels **8** are connected in parallel through the transaxle **1**, and the power of the engine **2** is also transmitted to the generator **4** in addition to the driving wheels **8**.

The transaxle **1** is a power transmission device formed by integrating a final drive (final reduction gear) including a differential gear **18** (differential device) and a transmission (reduction gear), and incorporates therein multiple mechanisms that is involved in power transmission between the driving source and a driven device. The transaxle **1** of the present embodiment is configured to enable high-low switching (switching between the high-speed stage and the low-speed stage). In the running in the parallel mode, the high-gear stage and the low-gear stage are switched by the control unit **5** according to, for example, the running state or the required output. Hereinafter, the running in the parallel mode is also referred to as "parallel driving".

The engine **2** is an internal combustion engine (gasoline engine, diesel engine) that uses gasoline or diesel oil as fuel. The engine **2** is a so-called lateral engine arranged laterally such that the direction of a crankshaft **2***a* (rotary shaft) coincides with the width direction of the vehicle **10**, and is fixed to the right side surface of the transaxle **1**. The crankshaft **2***a* is positioned in parallel to the drive shaft **9** of the drive wheels **8**. The operating state of the engine **2** is controlled by the control unit **5**.

The motor **3** and the generator **4** of the present embodiment are each an electric motor generator having both a function as an electric motor and a function as a generator. The motor **3** mainly functions as an electric motor to drive the vehicle **10**, and functions as a generator during regeneration. The generator **4** functions as an electric motor (starter) when starting the engine **2**, and generates electric power using the engine power when the engine **2** is operating. An inverter (not shown) for converting a direct current and an alternating current is provided around (or in) each of the motor **3** and the generator **4**. Each of the rotation speeds of the motor **3** and the generator **4** is controlled by controlling the inverter. Incidentally, the operating states of the motor **3**, the generator **4**, and the inverters are controlled by the control unit **5**.

FIG. **2** is a side view of the power train **7** as viewed from the left side. The powertrain **7** includes the engine **2**, the motor **3**, the generator **4**, and the transaxle **1**. In FIG. **2**, the engine **2** is omitted.

In the vehicle **10**, the control unit **5** for integrally controlling various devices mounted on the vehicle **10**. Further, the vehicle **10** includes an acceleration opening sensor **41** that detects the depression amount of the accelerator pedal (degree of acceleration opening), a wheel speed sensor **42** that detects the wheel speed Nw representing a rotation speed of the wheel, a motor rotation speed sensor **43** (first rotating electric machine speed sensor) that detects the rotation speed Nm (first rotation speed) of the motor **3**, a generator rotation speed sensor **44** (second rotating electric machine sensor) that detects a rotation speed Ng of the generator **4** (second rotation speed). The data detected by each of the sensors **41** to **44** is transmitted to the control unit **5**. The motor rotation speed sensor **43** and the generator rotation speed sensor **44** have higher detection precision than that of the wheel speed sensor **42**.

The control unit **5** is an electronic controller configured to be an LSI device or an embedded electronic device in which, for example, a microprocessor, a ROM, a RAM, and the like are integrated, and integrally controls various devices mounted on the vehicle **10**. The control unit **5** of the present embodiment selects a running mode in accordance with a required output of the driver or the like, controls various devices (e.g., the engine **2** and the motor **3**) according to the selected running mode, and also controls the disengaging state of the clutches **20** and **30** in the transaxle **1**. This control will be described below.

[2. Transaxle]

FIG. **3** is a skeleton diagram of a powertrain **7** including the transaxle **1** of the present embodiment. As shown in FIGS. **2** and **3**, the transaxle **1** is provided with six shafts **11**-**16** arranged in parallel to each other. Hereinafter, a rotary shaft connected coaxially with the crankshaft **2***a* is referred to as an input shaft **11**.

Similarly, rotary shafts connected coaxially with the drive shaft **9**, a rotary shaft **3***a* of the motor **3**, a rotary shaft **4***a* of the generator **4** are referred to as an output shaft **12**, a motor shaft **13**, a generator shaft **14**, respectively. Further, the rotary shaft disposed on the power transmission path between the input shaft **11** and the output shaft **12** is referred to as a first counter shaft **15**, and the rotary shaft disposed on the power transmission path between the motor shaft **13** and the output shaft **12** referred to as a second counter shaft **16**. The both ends of each of the six shafts **11**-**16** are journaled to a casing **1**C through non-illustrated bearings.

Three power transmission paths connected to the output shaft **12** are formed inside the transaxle **1**. Specifically, as shown by a two-dotted chain line in FIG. **2**, a power transmission path (hereinafter referred to as "a first path **51**") from the motor **3** to the output shaft **12** through the motor shaft **13**, a power transmission path (hereinafter referred to as "a second path **52**") from the engine **2** to the output shaft **12** through the input shaft **11**, and a power transmission path (hereinafter referred to as "a third path **53**") from the engine **2** to the generator shaft **14** through the input shaft **11** are formed. Here, the first path **51** and the second path **52** are driving-power transmission paths, the third path **53** is a power-generation-power transmission path.

The first path **51** (first power transmission path) is a path related to power transmission between the motor **3** and the drive wheels **8**, which is involved in the power transmission of the motor **3**. On the first path **51**, the motor shaft **13** to which power is transmitted by rotating in synchronization with the motor **3** and a second counter shaft **16** to which the power of the motor shaft **13** power is transmitted are provided, and, on an intermediate point of the first path **51**, a first dog clutch **20** (first connecting/disconnecting mechanism, dog clutch) that is to be described below and that disengages the power transmission through the first path **51** is interposed.

On the second path **52** (second power transmission path), the input shaft **11** to which power is transmitted by rotating in synchronization with the generator **4** and a first counter shaft **15** to which the power of the input shaft **11** power is transmitted are provided, and on an intermediate point of the second path **52**, a second dog clutch **30** (second connecting/disconnecting mechanism, dog clutch) that is to be described below and that disengages the power transmission through the second path **52** and switches between high and low is interposed.

The third path **53** is a path relating to power transmission between the engine **2** and the generator **4**, and is involved in power transmission at the start of the engine and power transmission at the time of electric power generation by the engine **2**.

Next, the configuration of the transaxle **1** will be detailed with reference to FIG. **3**. In the following description, a "fixed gear" means a gear provided integrally with a shaft and rotates in synchronization with the shaft (incapable of relative rotating). Further, the "idle gear" means a gear which is rotatably pivoted to the shaft.

The input shaft **11** is provided with, in sequence from the side near to the engine **2**, a fixed gear **11***a*, the second dog clutch **30** on the high side (hereinafter, referred to as "the high-side dog clutch **30**H"), an idle gear **11**H, and a fixed gear **11**L. Further, the first counter shaft **15** is provided with, in sequence from the side near to the engine **2**, a fixed gear **15***a*, a fixed gear **15**H, an idle gear **15**L, the second dog clutch **30** on the low side (hereinafter, referred to as "the low-side dog clutch **30**L").

The fixed gear **11***a* of the input shaft **11** always meshes with the fixed gear **14***a* provided on the generator shaft **14**. This means that the input shaft **11** and the generator shaft **14** are connected via two fixed gears **11***a* and **14***a* to make it possible to transmit power between the engine **2** and the generator **4**. Further, the fixed gear **15***a* of the first counter shaft **15** always meshes with a ring gear **18***a* of the differential **18** provided on the output shaft **12**.

The idle gear **11**H of the input shaft **11** has more teeth than the adjacent fixed gear **11**L, and always meshes with the fixed gear **15**H of the first counter shaft **15** to form a high-gear stage. Further, the fixed gear **11**L of the input shaft **11** always meshes with the idle gear **15**L of the first counter shaft **15** to form a low-gear stage. The idle gears **11**H and **15**L have dog gears **11***d* and **15***d* provided integrally on the side surface of each tooth surface portion meshing with the fixed gears **15**H and **11**L, respectively. Non-illustrated dog teeth are provided at the end portions (edges on radially outer parts) of the dog gears **11***d* and **15***d*.

The high-side clutch **30**H and the low-side clutch **30**L that constitute the second dog clutch **30** are clutch mechanisms provided on the second path **52**, and has a function to switch between the high-gear stage and the low-gear stage in addition to a function of disengaging power through the second path **52**. In cases where the running mode is the EV mode or the series mode, the second dog clutch is disengaged; and in cases where the running mode is the parallel mode, the second dog clutch **30** is engaged. In the present embodiment, when the running mode is the parallel mode, one of the high-side dog clutch **30**H and the low-side dog clutch **30**L is engaged and the other is disengaged. Incidentally, which of the clutches **30**H, **30**L is engaged is determined on the basis of, for example, the running state and the required output of the vehicle **10**.

The high-side dog clutch **30**H has a hub **31**H fixed to the input shaft **11** and an annular sleeve **32**H. Further, the low-side dog clutch **30**L has a hub **31**L fixed to the first counter shaft **15** and an annular sleeve **32**L. The sleeves **32**H, **32**L are incapable of rotating relative to the respective hubs **31**H, **32**L and are coupled to the respective hubs **31**H, **31**L so as to be slidable in the axial direction of the hubs **31**H, **31**L. Each of the sleeves **32**H, **32**L slides in the axis direction by the control unit **5** controlling a non-illustrated actuator (e.g. servo motor). A stroke sensor that detects a movement amount (stroke amount) (not shown) is provided near each of the sleeves **32**H, **32**L. Further, spline teeth (not shown) that mesh with the dog teeth of the dog gears **11***d* and **15***d* are provided radially inward parts of the sleeves **32**H and **32**L, respectively.

In a state where the sleeve **32**H engages with the dog gear **11***d*, the driving force from the engine **2** is transmitted to the output shaft **12** through the gear pair **11**H and **15**H on the high side. Conversely, in a state where the sleeve **32**H is disengaged from the dog gear **11***d*, the idle gear **11**H becomes idle state so that the second path **52** comes into a state the power transmission on the high side of the second path **52** is shut. Further, in a state where the sleeve **32**L engages with the dog gear **15***d*, the driving force from the engine **2** is transmitted to the output shaft **12** through the gear pair **11**L and **15**L on the low side. In contrast, in cases where the sleeve **32**L is separated from the dog gear **15***d*, the idle gear **5**L becomes idle state so that the second path **52** comes into a state the power transmission on the low side of the second path **52** is shut.

The second counter shaft **16** is provided with, in sequence from the side near to the engine **2**, a first dog clutch **20**, an idle gear **16**M, a parking gear **19**, and a fixed gear **16***a*. The fixed gear **16***a* always engages with the ring gear **18***a* of the differential **18**. The parking gear **19** is a component constituting the parking locking device. When the P-range is selected by the driver, the parking gear **19** engages with a parking plug (not shown) to inhibit rotation of the second counter shaft **16** (i.e., output shaft **12**).

The idle gear **16**M has more teeth than the fixed gear **13***a* provided on the motor shaft **13**, and always meshes with the fixed gear **13***a*. The idle gear **16**M has dog gears **16***d* provided integrally on the right side of the tooth surface portion meshing with the fixed gear **13***a*. At the tip portion of the dog gear **16***d*, dog teeth are provided. The first dog clutch **20** has a hub **21** which is fixed to the second counter shaft **16**, and an annular sleeve **22** which is incapable of relatively rotate around the hub **21** (second counter shaft **16**) and is slidably coupled to the hub **21** in the axial direction. The sleeve **22** slides in the axis direction by the control unit **5** controlling a non-illustrated actuator and the movement amount (stroke amount) of the sleeve **22** is detected by a non-illustrated stroke sensor. Spline teeth (not shown) that mesh with the dog teeth at the tip of the dog gear **16***d* are provided radially inward of the sleeve **22**.

In the present embodiment, the first dog clutch **20** is engaged when the running mode is the EV mode or the series mode, or when the running mode is the parallel mode and motor assist is required. That is, the sleeve **22** is meshed (engaged) with the dog gear **16***d*, and the driving force from the motor **3** is transmitted to the output shaft **12**. Further, when the running mode is a parallel mode and the assist by the motor **3** is not required, the first dog clutch **20** is disengaged. That is, the sleeve **22** and the dog gear **16***d* are separated, and the idle gear **16**M comes into an idle state, so that the power transmission of the first path **51** comes into a state the power transmission on the first path **51** is shut.

Further, in the transaxle **1** of the present embodiment, the first path **51** and the second path **52** are formed such that the number of transmission stages from the output shaft **12** to the motor **3** is two in contrast to the number of transmission stages from the output shaft **12** to the generator **4** being three. This means that, in the present embodiment, the power of the generator **4** is shifted at three positions of: the fixed gear **14***a* and the fixed gear **11***a*; the high-gear stage or the low-gear stage; and the fixed gear **15***a* and the ring gear **18***a* until reaching the output shaft **12**. In contrast, the power of the motor **3** is shifted at two positions of: the fixed gear **13***a* and the idle rolling gear **16**M; and the fixed gear **16***a* and the ring gear **18***a* until reaching the output shaft **12**.

[3. Overview of Control]

In the transaxle **1** described above, the control unit **5** selects a running mode in accordance with, for example, a running state of the vehicle **10** and the required output of the driver and also controls the engaging-disengaging states of the clutches **20**, **30** in accordance with the selected running mode. The control unit **5** of the present embodiment synchronizes the rotation speed of the driving source side with the rotation speed of the output shaft **12** side when engaging the clutches **20**, **30**. In this synchronization, the control unit **5** changes a value to be referred to so as to enhance the precision thereof according to the circumstance.

Further, in the state where the first dog clutch **20** is engaged, the control unit **5** calculates a deviation X (=Nam−Nw) between the value Nw detected by the wheel speed sensor **42** and the value Nam obtained by converting (calculating) the value Nm detected by the motor rotation speed sensor **43** into an axle rotation speed value, and stores the deviation X. Similarly, in the state where the second dog clutch **30** is engaged, the control unit calculates a deviation Y (=Nag−Nw) between the value Nw detected by the wheel speed sensor **42** and the value Nag obtained by converting (calculating) a value Ng detected by the generator rotation speed sensor **44** into an axle rotation speed and stores the deviation Y. These deviations (misalignments) X and Y are used to correct the wheel speed Nw detected when the clutches **20** and **30** are in the disengaging state (during being disengaged), and are calculated as the axle rotational speeds Nax and Nay at that time. The deviation X, Y will be described below.

Hereinafter, when two deviations X and Y are distinguished from each other, the former is called a first deviation X, and the latter is called a second deviation Y. While the state of the clutches **20** and **30** are in the disengaging state, the rotation can be accurately synchronized by correcting the wheel speed Nw on the basis of the calculated deviations X and Y and calculating the axle rotation speeds Nax and Nay.

Furthermore, when the first deviation X is a predetermined value Xp or more, the control unit **5** of the present embodiment determines the wheel speed sensor **42** and/or the motor rotation speed sensor **43** have a possibility of having a failure, and prohibits disengagement of the first dog clutch **20**.

The control unit **5** of the present embodiment periodically calculates and stores (updates) the above deviations X, Y during a single driving cycle (from IG-ON to IG-OFF), calculates the average values Xav, Yav of the deviations X, Y, respectively. These average values Xav, Yav are added to the wheel speed Nw detected during the disengagement of the clutch **20** or **30**, and are calculated as the axle rotation speed Nax, Nay at that time. Hereinafter, the rotation synchronization of each of the clutches **20**, **30** will be detailed.

When the first dog clutch **20** in the disengaging state is to be engaged, the rotation speed of the motor **3** side (dog gear **16***d*) can be obtained from the motor rotation speed Nm detected by the motor rotation speed sensor **43** and the gear ratio of the fixed gears **13***a*, **16**M. On the other hand, the rotation speed of the output shaft **12** side (sleeve **22**) is determined from the axle rotation speed being the rotation speed of the output shaft **12** and the gear ratio of the fixed gear **16***a* and the ring gear **18***a*.

Here, when the first dog clutch **20** is to be engaged in a state where the second dog clutch **30** is engaged, the axle rotation speed Nag is calculated on the basis of the generator rotation speed Ng detected by the generator rotation speed sensor **44**. That is, in cases where the first dog clutch **20** which is disengaged because the motor assist is not required during the parallel running is to be reengaged, the rotation is synchronized on the basis of the motor rotation speed Nm and the generator rotation speed Ng without using the wheel speed Nw.

In contrast, in cases where the first dog clutch **20** is to be engaged under the disengaging state of the second dog clutch **30**, since the generator rotation speed Ng is not able to be used, the axle rotation speed Nay is calculated on the basis of the wheel speed Nw detected by the wheel speed sensor **42** and the average value Yav stored (average value of the second deviation Y). For example, when the parallel mode is switched to the EV mode or the series mode, the axle rotation speed Nay is calculated by correcting the wheel speed Nw on the basis of the average value Yav of the second deviation Y stored when the second dog clutch **30** is in the engaging state and rotation is synchronized on the basis of the axle rotation speed Nay and the motor rotation speed Nm.

Further, when the high-side dog clutch **30**H in the disengaging state is to be engaged, the rotation speed of the generator **4** side (sleeve **32**H) can be obtained by the generator rotation speed Ng detected by the generator rotation speed sensor **44** and the gear ratio of the fixed gear **11***a*,**14***a*. On the other hand, the rotation speed of the output shaft **12** side (dog gear **11***d*) is obtained from the axle rotation speed, the gear ratio of the high-gear stage, and the gear ratio of the fixed gear **15***a* and the ring gear **18***a*.

Here, in cases where the high-side dog clutch **30**H is to be engaged under the engaging state of the first dog clutch **20**, the axle rotation speed Nam is calculated on the basis of the motor rotation speed Nm detected by the motor rotation speed sensor **43**. For example, when the EV mode or the series mode is switched to the parallel mode (high-gear stage), for example, rotation is synchronized on the basis of the motor rotation speed Nm and the generator rotation speed Ng without using the wheel speed Nw.

In contrast, when the high-side dog clutch **30**H is to be engaged in the engaging state of the first dog clutch **20**, since the motor rotation speed Nm is not able to be used, the axle rotation speed Nax is calculated on the basis of the wheel speed Nw detected by the wheel speed sensor **42** and the average value Xav stored (the average value of the first deviation X). For example, when the low-gear stage is switched to the high-gear stage during the parallel running not requiring motor assist, the axle rotation speed Nax is calculated by correcting the wheel speed Nw on the basis of the average value Xav of the first deviation X stored when the first dog clutch **20** is in the engaging state (during engagement) and the rotation is synchronized on the basis of the axle rotation speed Nax and the generator rotation speed Ng.

Further, in cases where the low-side clutch **30**L in the disengaging state is to be engaged, the rotation speed of the generator **4** side (dog gear **15***d*) is obtained from the generator rotation speed Ng, the gear ratio of the fixed gear **11***a*, **14***a*, and the gear ratio of the low-gear stage. On the other hand, the rotation speed of the output shaft **12** side (sleeve **32**L) is obtained from the axle rotation speed, and the gear ratio of the fixed gear **15***a* and the ring gear **18***a*. Here, the low-side dog clutch **30**L is to be engaged in the engaging state of the first dog clutch **20**, the axle rotation speed Nam is calculated on the basis of the motor rotation speed Nm likewise the high side.

In contrast, when the low-side dog clutch **30**L is to be engaged in the engaging state of the first dog clutch **20**, since the motor rotation speed Nm is not able to be used, the axle rotation speed Nax is calculated on the basis of the wheel speed Nw detected by the wheel speed sensor **42** and the average value Xav stored (the average value of the first deviation X) likewise the high side. For example, when the high-gear stage is switched to the low-gear stage during the parallel running not requiring motor assist, the axle rotation speed Nax is calculated by correcting the wheel speed Nw on the basis of the average value Xav of the first deviation X stored while the first dog clutch **20** is engaged and the rotation is synchronized on the basis of the axle rotation speed Nax and the generator rotation speed Ng.

[4. Control Configuration]

The control unit **5** is provided with a selector **5**A, a first calculator **5**B, a monitoring unit **5**C, a second calculator **5**D, a controller **5**E, and a prohibitor **5**F as elements for executing clutch engaging and disengaging control including the above-described rotation synchronization and prohibition of disengaging the first dog clutch **20**. These elements indicate some functions of the program executed by the control unit **5**, and are assumed to be implemented by software. However, some or all of the functions may be achieved by hardware (electronic circuits), or may be achieved by a combination of software and hardware.

The selector **5**A selects a running mode from the EV mode, the series mode, and the parallel mode on the basis of the driving state of the vehicle **10**, the required output of the driver, and the charging state of battery **6**. Here, the required output is the output (output demand) the driver demands with respect to the vehicle **10**, and is estimated (calculated) on the basis of, for example, the degree of accelerator opening or the vehicle speed. The selector **5**A selects the EV mode when the vehicle **10** starts or stops, for example. In addition, the selector **5**A selects the parallel mode when the running load or vehicle speed is high, and selects the series mode when the charging rate of the battery **6** is low. While the parallel mode is selected, the selector **5**A of the present embodiment determines, for example, on the basis of the required output or the vehicle speed, whether or not motor assist is required.

The first calculator **5**B calculates the axle rotation speed Nam based on the motor rotation speed Nm in the engaging state of the first dog clutch **20**. The first calculator **5**B of the present embodiment, under the engaging state of the second dog clutch **30**, also calculates the axle rotation speed Nag based on the generator rotation speed Ng. The first calculator **5**B may calculate the axle rotation speed Nam, Nag based on the motor rotation speed Nm and the generator rotation speed Ng, respectively, when both clutches **20**, **30** are engaged.

The monitoring unit **5**C calculates (obtains) the deviation X (first deviation) between the axle rotational speed Nam calculated by the first calculator **5**B and the wheel speed Nw. The monitoring unit **5**C of this embodiment also calculates (obtains) the deviation Y (second deviation) between the axle rotation speed Nag calculated by the first calculator **5**B and the wheel speed Nw. That is, when the axle rotation speeds Nam and Nag are transmitted from the first calculator **5**B, the values X (=Nam−Nw) and Y (=Nag−Nw) are calculated by subtracting the wheel speed Nw detected at that time from the respective values Nam and Nag. The monitoring unit **5**C preferably calculates the deviations X, Y when the wheels are not slipping or locking while the vehicle **10** is running (when running normally).

The monitoring unit **5**C of the present embodiment calculates and stores the first deviation X and the second deviation Y periodically during running of the vehicle **10**. Then, the average value Xav of all the stored first deviations X is calculated, and is stored in place of the currently stored average value Xav (i.e., the average value Xav is updated). The average value Yav of the second deviation Y is calculated and stored (updated) in the same manner. The monitoring unit **5**C may store a single average value Xav of the first deviation X and a single average value Yav of the second deviation Y, or may associate the deviations X and Y with driving state (e.g., vehicle speed and load) and thereby store (i.e., multiple) average values Xav and Yav for each driving state.

The second calculator **5**D calculates the axle rotation speed Nax by correcting the wheel speed Nw on the basis of the first deviation X calculated (stored) in the disengaging state of the first dog clutch **20**. In the disengaging state of the second dog clutch **30**, the second calculator **5**D of the present embodiment also calculates the axle rotation speed Nay by also correcting the wheel speed Nw on the basis of the second deviation Y. When the average values Xav and Yav are stored in the monitoring unit **5**C for each driving state, the second calculating unit **5**D preferably calculates the axle rotational speeds Nax and Nay by selecting the average values Xav and Yav corresponding to the driving state at the time of the calculation.

In other words, in the control unit **5**, the axle rotation speed Nam is calculated by the first calculator **5**B in the engaging state of the first dog clutch **20**, and the axle rotation speed Nax is calculated by the second calculator **5**D in the disengaging state of the first dog clutch **20**. Further, the axle rotation speed Nag is calculated by the first calculator **5**B in the engaging state of the second dog clutch **30** and the axle rotation speed Nay is calculated by the second calculator **5**D in the disengaging state of the second dog clutch **30**.

The controller **5**E controls the engaging-disengaging state of the first dog clutch **20** and the engaging-disengaging state of the second dog clutch **30** in accordance with the running mode selected by the selector **5**A. Specifically, when the first dog clutch **20** in the disengaging state is to be engaged, the controller **5**E synchronizes rotation by controlling the torque of the motor **3** such that the rotation speed of the motor **3** side (dog gear **16***d*) coincides with the rotation speed of the output shaft **12** side (sleeve **22**). Then, the control unit **5**A moves the sleeve **22** in a direction toward the dog gear **16***d* by controlling the actuator. Incidentally, the controller **5**E of the present embodiment includes a function as a sub-controller that controls the engaging-disengaging state of the first dog clutch **20**.

When the first dog clutch **20** is to be engaged in the engaging state of the second dog clutch **30**, the controller **5**E obtains the rotation speed of the output shaft **12** side using the axle rotation speed Nag calculated by the first calculator **5**B. That is, in this case, the controller **5**E engages the first dog clutch **20** after controlling the motor **3** such that the rotation of the first dog clutch **20** is synchronized on the basis of the axle rotation speed Nag calculated by the first calculator **5**B and the motor rotation speed Nm detected by the motor rotation speed sensor **43**.

Further, when the first dog clutch **20** is to be engaged in the disengaging state of the second dog clutch **30**, the controller **5**E obtains the rotation speed of the output shaft **12** side using the axle rotation speed Nay calculated by the second calculator **5**D. That is, in this case, the controller **5**E engages the first dog clutch **20** after controlling the motor **3** such that the rotation of the first dog clutch **20** is synchronized on the basis of the axle rotation speed Nay calculated by the second calculator **5**D and the motor rotation speed Nm detected by the motor rotation speed sensor **43**. The above control precisely obtains the axle rotation speed, regardless of the engaging-disengaging state of the second dog clutch **30**, so that the precision of the rotation synchronization can be enhanced.

Further, when the rotation speed of the generator **4** side is to be made coincide with the rotation speed of the output shaft **12** side in order to engage the second dog clutch **30**, the controller **5**E controls the torque of the generator **4** to accomplish the rotation synchronization. Then, the controller **5**E moves the sleeve **32**H or **32**L in a direction toward the dog gear **11***d* or **15***d* by controlling the actuator. When the second dog clutch **30** is to be engaged in the engaging state of the first dog clutch **20**, the controller **5**E obtains the rotation speed of the output shaft **12** side using the axle rotation speed Nam calculated by the first calculator **5**B. That is, in this case, the controller **5**E engages the second dog clutch **30** after controlling the generator **4** on the basis of the axle rotation speed Nam calculated by the first calculator **5**B and the generator rotation speed Ng detected by the generator rotation speed sensor **44** such that the second clutch **30** synchronizes the rotation.

Further, when the second dog clutch **30** is to be engaged in the disengaging state of the first dog clutch **20**, the controller **5**E obtains the rotation speed of the output shaft **12** side using the axle rotation speed Nax calculated by the second calculator **5**D. That is, in this case, the controller **5**E engages the second dog clutch **30** after controlling the generator **4** on the basis of the axle rotation speed Nax calculated by the second calculator **5**D and the generator rotation speed Ng detected by the generator rotation speed sensor **44** such that the second clutch **30** synchronizes the rotation. The above control precisely obtains the axle rotation speed, regardless of the engaging-disengaging state of the first dog clutch **20**, so that the precision of the rotation synchronization can be enhanced.

When the first deviation X stored in the monitoring unit **5**C is a predetermined value Xp or more, the prohibitor **5**F determines that at least one of the wheel speed sensor **42** and the motor rotation speed sensor **43** to have a possibility of having a failure, and prohibits the disengagement of the first dog clutch **20**. The predetermined value Xp is set in advance to a value that can discriminate the presence or absence of a failure. The prohibitor **5**F determines whether or not the first deviation X is equal to or greater than the predetermined value Xp regardless of the running modes or the engaging-disengaging states of the clutches **20** and **30**. The prohibitor **5**F may determine that at least one of the wheel speed sensor **42** and the generator rotation speed sensor **44** has a possibility of having a failure on the basis of the second deviation Y and prohibit engagement of the second dog clutch **30**. Further, when determining that there is a possibility of failure, the control unit **5** may light a warning light indicating a failure, or may record a signal indicating a failure.

[5. Flow Chart]

FIGS. **4**(*a*) and **4**(*b*) are flowchart examples implemented in the monitoring unit **5**C of the control unit **5** described above. When the EV mode or the series mode is selected in the selector **5**A, the flowchart of FIG. **4**(*a*) is executed in a predetermined calculation cycle, and when the parallel mode is selected, the flowchart of FIG. **4**(*b*) is executed in a predetermined calculation cycle.

If the EV mode or series mode is selected, it is determined that the first dog clutch **20** is in an engaging state and the second dog clutch **30** is in a disengaging state. In this case, as shown in FIG. **4**(*a*), the motor rotation speed Nm detected by the motor rotation speed sensor **43** and the wheel speed Nw detected by the wheel speed sensor **42** are obtained (Step S**1**). Then, the axle rotation speed Nam is calculated on the basis of the motor rotation speed Nm (Step S**2**), and the first deviation X is calculated by subtracting the wheel speed Nw from the axle rotation speed Nam (Step S**3**). Then, in Step S**4**, the average value Xav of the first deviation X is calculated, and the new average value Xav is stored (updated).

If the parallel mode is selected, it is determined the second dog clutch **30** is in the engaged state, and the engaging-disengaging state of the first dog clutch **20** is controlled in the disengaged state depending on whether or not motor assist is required. In this case, as shown in FIG. **4**(*b*), the generator rotation speed Ng detected by the generator rotation speed sensor **44** and the wheel speed Nw detected by the wheel speed sensor **42** is obtained (Step S**11**). Then, the axle rotation speed Nag is calculated on the basis of the generator rotation speed Ng (Step S**12**), and the second deviation Y calculated by subtracting the wheel speed Nw from the axle rotation speed Nag is calculated (Step S**13**). Then, in Step S**14**, the average value Yav of the second deviation Y is calculated, and the new average value Yav is stored (updated).

FIG. **5** is an flowchart example executed in the selector **5**A, the first calculator **5**B, the second calculator **5**D, and the controller **5**E of the control unit **5** described above, and is executed in parallel with the flowcharts of FIGS. **4**(*a*) and **4**(*b*). This flowchart is executed at a predetermined calculation cycle when, for example, the main power supply of the vehicle **10** is turned on. It should be noted that this calculation cycle does not need to be the same as the calculation cycle when the flowcharts of FIGS. **4**(*a*) and **4**(*b*) are implemented.

As shown in FIG. **5**, in Step T**1**, the information detected by each of the sensors **41** to **44** is obtained, and in Step T**2**, it is determined whether or not the current running mode is the EV mode or the series mode. If the EV mode or the series mode, it is determined in Step T**3** whether or not a condition for switching to the parallel mode is satisfied. The condition includes, for example, the vehicle speed equal to or higher than a predetermined vehicle speed, and the running load equal to or higher than a predetermined load. If this condition is satisfied, the parallel mode is set in Step T**4**, and process (Steps T**5** to T**7**) for engaging the second dog clutch **30** is performed.

First, the axle rotation speed Nam is calculated on the basis of the motor rotation speed Nm in Step T**5**, the generator **4** is controlled in Step T**6** on the basis of the axle rotation speed Nam and the generator rotation speed Ng obtained in Step T**1** such that the rotation is synchronized. Then, in Step T**7**,when rotation is synchronized, the actuator is controlled to engage second dog clutch **30**. That is, the high-side dog clutch **30**H or the low-side dog clutch **30**L is engaged to make the power of the engine **2** into a state transmittable to the output shaft **12** and the flow is returned. If it is determined No in Step T**3**, the EV mode or the series mode is kept, and the flow is returned.

On the other hand, if it is determined that the mode is the parallel mode in Step T**2**, the process proceeds to Step T**8** to determine whether or not a switching condition to the EV mode or the series mode is satisfied. The condition includes, for example, the vehicle speed lower than a predetermined vehicle speed, and the running load lower than a predetermined load. If this condition is not satisfied, that is, when the parallel mode is to be kept, whether motor assist is required is determined in Step T**9**.

If motor assist is not required, the process proceeds to Step T**10** to disengage the first dog clutch **20**. Next, it is determined whether or not the switching condition between the high-gear stage and the low-gear stage is satisfied in Step T**11**, and if the condition is not satisfied, the flow is returned. On the contrary, if the condition is satisfied, the process (steps T**12** to T**14**) for the high-low switching is performed. Here, the high-low switching condition includes, for example, the vehicle speed in a high speed range and a high required output.

In Step T**12**, the axle rotation speed Nax is calculated from the wheel speed Nw obtained in Step T**1** and the average value Xav of the first deviation X stored in Step S**4** of FIG. **4**(*a*). In Step T**13**, rotation synchronization is carried out on the basis of the axle rotation speed Nax and the generator rotation speed Ng obtained in Step T**1**, and the actuator is controlled to thereby switch between the high-gear stage and the low-gear stage (Step T**14**). Incidentally, in Step T**13**, since the axle rotation speed Nax considering the average value Xav of the first deviation X is used, the precision of the rotation synchronization is enhanced.

Further, if it is determined, during parallel running (No in Step T**8**), that the motor assist is required in Step T**9**, the process proceeds to Step T**15**, in which whether the first dog clutch **20** is engaged is determined. If the first dog clutch **20** is in the engaging state, the flow is returned because the motor assist can be immediately executed. On the other hand, if the first dog clutch **20** is in the disengaging state, the process proceeds to Step T**16** to calculate the axle rotation speed Nag from the generator rotation speed Ng. Then, the rotation synchronization is performed on the basis of the axle rotation speed Nag and the motor rotation speed Nm obtained in Step T**1** (Step T**17**), and the actuator is controlled to thereby engage the first dog clutch **20** (Step T**18**). This enables motor assist.

Further, when the switching condition to EV mode or series mode is satisfied in Step T**8**, the process proceeds to Step T**20** to set EV mode or series mode. Then, the second dog clutch **30** is disengaged (Step T**21**), whether the first dog clutch **20** is in the engaging state is determined (Step T**22**). If the first dog clutch **20** is engaged, this flow is returned because the running state can be switched directly to the motor running.

On the other hand, if the first dog clutch **20** is disconnected, the process proceeds to Step T**23** to calculate the axle rotation speed Nay from the wheel speed Nw obtained in Step T**1** and the average value Yav of the second deviation Y stored in Step S**14** of FIG. **4**(*b*). In Step T**24**, the rotation synchronization is performed on the basis of the axle rotation speed Nay and the motor rotation speed Nm acquired in Step T**1**, the first dog clutch **20** is engaged by controlling the actuator (Step T**25**). Incidentally, in Step T**24**, since the axle rotation speed Nay considering the average value Yav of the second deviation Y is used, the precision of the rotation synchronization is enhanced.

[6. Effect]

(1) In the control unit **5** described above, when the clutches **20**, **30** are in the engaging state, the axle rotation speed Nam, Nag are calculated on the basis of the values Nm, Ng detected by the rotation speed sensor **43** and **44** with high detection accuracy, and the deviations X, Y of the axle rotation seed Nam, Nag and the value Nw detected by the wheel speed sensor **42** is calculated and stored. Therefore, even under a situation in which only the value Nw detected by the wheel speed sensor **42** can be used (i.e., while the connecting/disconnecting mechanisms **20**, **30** are disengaged), it is possible to calculate the axle rotation speed accurately. Consequently, for example, as in the above embodiment, it is possible to enhance the accuracy of the rotation synchronization when the clutches **20**, **30** are engaged which are disposed on the path **51** between the motor **3** and the output shaft **12** and the path **52** between the generator **4** and the output shaft **12**, so that vibration and noise during clutch engagement can be suppressed.

(2) The monitoring unit **5**C described above periodically calculates the deviations X, Y while the vehicle **10** is running, and stores the average values Xav, Yav thereof, which can increase the calculation precision in the second calculator **5**D. In addition, in cases where the monitoring unit **5**C calculates deviations X and Y for each driving state (i.e., calculates multiple deviations X and Y), since the second calculator **5**D selects the average values Xav, Yav corresponding to the driving state at the time of calculation, it is possible to further increase the calculation accuracy of the axle rotation speed.

(3) The above-described controller **5**E uses, when the rotation of the second dog clutch **30** is to be synchronized to engage the second dog clutch **30** in the disengaged state of the first dog clutch **20**, the axle rotation speed Nax calculated by the second calculator **5**D. Further, when the rotation of the first dog clutch **20** is to be synchronized to engage the first dog clutch **20** in the disengaged state of the second dog clutch **30**, the controller **5**E uses the axle rotation speed Nay calculated by the second calculator **5**D. Thus, when one of the clutches **30**, **20** is to be engaged in a state where the other clutch **20**, **30** is disengaged, since the wheel speed Nw uses the axle rotation speeds Nax, Nay considering deviations X, Y, it is possible to increase the rotation synchronization accuracy and thereby suppress the vibration and noise at the time of engagement of the clutches **20**, **30**.

(4) Further, since the transaxle **1** described above includes transmission stages from the output shaft **12** to the motor **3** less in number than the transmission stages from the output shaft **12** to the generator **4**, the control on the rotation synchronization can be enhanced by using the axle rotation speed Nam based on the motor rotation speed Nm having less error in engaging the second dog clutch **30**.

(5) The vehicle **10** described above is a hybrid vehicle including the engine **2** and the motor **3** for driving and a generator **4** for power generation, and the second dog clutch **30** interposed on the second path **52** has a high-low switching function in addition to a function to disengage the power transmission. Therefore, even if the motor **3** is disconnected from the output shaft **12** when switching between the high-gear stage and the low-gear stage while the vehicle **10** is running mainly on the engine **2** (i.e., during parallel running), it is possible to synchronize the rotation using the axle rotation speed Nax calculated by the second calculator **5**D, quiet high-low switching can be achieved. Besides, the vehicle **10** can be driven by efficiently utilizing the engine output, which can enhance the power performance.

(6) The above-described controller **5**E uses, when the rotation of the second dog clutch **30** is to be synchronized to engage the second dog clutch **30** in the engaging state of the first dog clutch **20**, the axle rotation speed Nam calculated by the first calculator **5**B. Further, when the rotation of the first dog clutch **20** is to be synchronized to engage the first dog clutch **20** in the state where the second dog clutch **30** is engaged, the controller **5**E uses the axle rotation speed Nag calculated by the first calculator **5**B. Thus, since, when one of the clutches **20**, **30** is engaged in a state where the other one of the clutches **30**, **20** is engaged, the axle rotation speeds Nam, Nag calculated on the basis of the values Nm, Ng of the rotation speed sensor **43**, **44** with high detection accuracy are used, it is possible to increase the rotation synchronization accuracy, and to suppress the vibration and the noise at the time of engagement of the clutch **20**, **30**.

(7) The above-described controller **5**E engages, when the second dog clutch **30** is to be engaged in a disengaging state of the first dog clutch **20**, the second dog clutch **30** after controlling the generator **4** on the basis of the generator rotation speed Ng and the axle rotation speed Nax calculated by the second calculator **5**D such that the rotation of the second dog clutch **30** is synchronized, vibration and noise at the time of engagement of the second dog clutch **30** can be suppressed, enhancing the accuracy of the rotation synchronization.

(8) Since, when the first dog clutch **20** is to be engaged from the disengaged state, the controller **5**E engages the first dog clutch **20** after controlling the motor **3** on the basis of the motor rotation speed Nm and the axle rotation speed Nay calculated by the second calculator **5**D such that the rotation of first dog clutch **20** is synchronized, vibration and noise at the time of engagement of the first dog clutch **20** can be suppressed, enhancing the accuracy of the rotation synchronization.

(9) When the first deviation X stored in the monitoring unit **5**C is a predetermined value Xp or more, i.e., when the first deviation X is large, the prohibitor **5**F described above determines that there is a high possibility that at least one of the motor rotation speed sensor **43** and the wheel speed sensor **42** has a failure and prohibits the disengagement of the first dog clutch **20**. This can avoid vibration and noise generation at the time of engagement of the first dog clutch **20**. Incidentally, when the prohibitor **5**F determines, based

on the second deviation Y, that there is a high possibility that at least one of the wheel speed sensor **42** and the generator rotation speed sensor **44** has a failure and prohibits the disengagement of the first dog clutch **30**, vibration and noise generation at the time of engagement of the second dog clutch **30** can be suppressed.

[7. Modifications]

In the embodiment described above, the vehicle **10** is assumed to be a two-front-wheel-drive hybrid vehicle that mounts the engine **2** and the motor **3** on the front side thereof. The method for calculating the axle rotation speed and the rotation synchronization control described above can be applied to, as shown by a two-dotted chain line in FIG. **1**, a four-wheel-drive hybrid vehicle that also mounts a rear motor **3**R on the rear side thereof. This means that the vehicle **10** may include a front motor **3** (first rotating electric machine) for driving the front wheels **8** and a rear motor **3**R (third rotating electric machine) for driving rear wheels **8**R.

The rear motor **3**R shown by a two-dotted chain line in FIG. **1** is connected via a second transaxle **60** to the axle connecting the right and left rear wheels **8**R. However, the second transaxle **60** does not include a clutch. That is, the rear motor **3**R is connected to the rear wheels **8**R without a clutch. Further, the vehicle is provided with a rear motor rotation speed sensor **48** for detecting the rotation speed of the rear motor **3**R (third rotating electric machine speed sensor) is provided.

In such a four-wheel-drive hybrid vehicle, when the wheel speed sensor **42** has a failure, the calculation of the axle rotation speed uses the value (rear motor rotation speed Nr) detected by the rear motor rotation speed sensor **48** instead of the wheel speed Nw. That is, when the wheel speed sensor **42** has a failure, the above-described second calculator **5**D calculates the rotation speed (axle rotation speed) of the axle **9** connected to the front wheels **8** (one of wheels) on the basis of the rotation speed Nr of the rear motor **3**R and the deviations X, Y or the average values Xav, Yav calculated (stored) by the monitoring unit **5**C. With this configuration, the calculation accuracy of the axle rotation speed can be ensured even at the time of a failure of the wheel speed sensor **42**.

The configuration of this modification may be applied to a hybrid vehicle in which the above-described power train **7** is mounted on the rear side thereof to allow the above motor **3** to drive rear wheels **8**R and the third rotating electric machine (motor) serving as a driving source is mounted on the front side thereof to drive the front wheels **8**. The control of this modification can be applied to a vehicle that includes at least a first rotating electric machine for driving one of a set of the front wheels **8** and a set of the rear wheels **8**R and a third evolving armature for driving the other set of the wheels without a connecting/disconnecting mechanism. Since the third rotating electric machine is connected to the wheel without being interposed by a clutch, the rotation speed of the third rotating electric machine can be used in place of the wheel side Nw regardless of the engaging-disengaging state of the clutch.

[8. Miscellaneous]

The contents of the method for calculating the axle rotation speed and the rotation synchronization control described above are examples, and are not limited to those described above. For example, the monitoring unit **5**C may calculate deviations X, Y only once while running, or may store (update) the deviations X, Y by overwriting with the calculated deviations X, Y in place of calculating and storing the average values Xav, Yay. Further, the prohibitor **5**F described above may be omitted, and a sub-controller for controlling the engaging-disengaging state of the first dog clutch **20** may be provided independently of the controller **5**E.

Further, in the above-described embodiment, when the first dog clutch **20** is to be engaged in the state where the second dog clutch **30** is disengaged, the axle rotation speed Nay is calculated by correcting the wheel speed Nw on the basis of the second deviation Y, but alternatively the axle rotation speed Nax may be calculated by correcting the wheel speed Nw on the basis of the first deviation X. Similarly, when the second dog clutch **30** is to be engaged in the state where the first dog clutch **20** is disengaged, the axle rotation speed Nax is calculated by correcting the wheel speed Nw on the basis of the first deviation X, but alternatively the axle rotation speed Nay may be calculated by correcting the wheel speed Nw on the basis of the second deviation Y. According to such a calculation method, even when the vehicle **10** has one rotating electric machine, the same operation and effect as those of the above-described embodiment can be obtained.

The structure of the transaxle **1** controlled by the control unit **5** described above is only an example, and is not limited to that described above. For example, in the transaxle **1** described above, the second dog clutch **30** is provided on each of the input shaft **11** and the first counter shaft **15**, but alternatively, a single second dog clutch may be provided either one of the shafts **11** and **15**. Further, both the first clutch mechanism and the second clutch mechanism are not limited to the dog clutches and may alternatively be clutch mechanisms such as a hydraulic friction clutch or an electromagnetic clutch. In addition, these clutch mechanisms may be disposed at positions other than those described above.

In addition, the above-described control can be performed at the time of engagement of a dog clutch even when one of the connecting/disconnecting mechanism on the first path **51** and the connecting/disconnecting mechanism on the second path **52** is a dog clutch and the other is a connecting/disconnecting mechanism of a hydraulic friction clutch, an electromagnetic clutch, or the like.

For example, when only the connecting/disconnecting mechanism of the first path **51** is a dog clutch, the rotation speed of the generator **4** (the first rotating electric machine) is detected by the generator rotation speed sensor **44** (the first rotating electric machine speed sensor), and the first calculator **5**B calculates the axle rotation speed Nag on the basis of the generator rotation speed Ng (the first rotation speed) in the engaging state of the connecting/disconnecting mechanism on the second path **52**. In addition, the monitoring unit **5**C calculates the deviation Y between the axle rotational speed Nag and the wheel speed Nw. Then, if the second calculator **5**D calculates the axle rotation speed Nay by correcting the wheel side Nw on the basis of the deviation Y in the disengaging state of the connecting/disconnecting mechanism on the second path **52**, the controller **5**E can synchronize the rotation accurately when causing the dog clutch on the first path **51** to engage regardless of the engaging-disengaging state on the second path **52**.

The relative positions of the engine **2**, the motor **3**, and the generator **4** to the transaxle **1** are not limited to those described above. Depending on these relative positions, the arrangement of the six axles **11** to **16** in the transaxle **1** may be set. The arrangement of the gears provided on the respective shafts in the transaxle **1** is also an example, and is not limited to the one described above.

Further, the configuration of the powertrain **7** described above is an example, and to a vehicle having a configuration other than the power train **7** described above, the method for calculating the axle rotation speed described above and the rotation synchronization control may be applied. It is satisfactorily that the vehicle is provided with at least a connecting/disconnecting mechanism disposed on a power transmission path between a rotating electric machine (e.g., motor, generator, motor generator) and the output shaft, a sensor for detecting the rotation speed of the rotating electric machine, and the wheel speed sensor.

The invention thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

DESCRIPTION OF REFERENCE SIGNS

2 engine
3 motor, front motor (first rotating electric machine)
3R rear motor (third rotating electric machine)
4 generator (first rotating electric machine, second rotating electric machine)
5 control unit
5B first calculator
5C monitoring unit
5D second calculator
5E controller (sub-controller)
5F prohibitor
8 driving wheel, front wheel, wheel
8R rear wheel, wheel
10 vehicle
12 output shaft
20 first dog clutch (first connecting/disconnecting mechanism, dog clutch)
30 second dog clutch (second connecting/disconnecting mechanism, dog clutch)
42 wheel speed sensor
43 motor rotation speed sensor (first rotating electric machine sensor)
44 generator rotation speed sensor (first rotating electric machine sensor, second rotating electric machine sensor)
48 rear motor rotation speed sensor (third rotating electric machine sensor)
51 first path (first power transmission path)
52 second path (second power transmission path)
Nag,Nam,Nax,Nay axle rotation speed
Ng generator rotation speed (first rotation speed, second rotation speed)
Nm motor rotation speed (first rotation speed)
Nw wheel speed
X first deviation
Xav average value
Xp predetermined value
Y second deviation
Yav average value

The invention claimed is:

1. A control unit for controlling a vehicle, the vehicle comprising a first connecting/disconnecting mechanism disposed on a first power transmission path between a first rotating electric machine mounted on the vehicle and an output shaft that drives a wheel, a first rotating electric machine speed sensor that detects a rotation speed of the first rotating electric machine as a first rotation speed, and a wheel speed sensor that detects a rotation speed of the wheel as a wheel speed, the control unit comprising:

a first calculator that calculates an axle rotation speed representing a rotation speed of the output shaft based on the first rotation speed in a state where the first connecting/disconnecting mechanism is engaged;

a monitoring unit that calculates a deviation between the axle rotation speed calculated by the first calculator and the wheel speed; and

a second calculator that calculates the axle rotation speed by calibrating the wheel speed based on the calculated deviation in a state where the first connecting/disconnecting mechanism is disengaged.

2. The control unit according to claim **1**, wherein the monitoring unit periodically calculates the deviation while the vehicle is running and stores an average value of a plurality of the deviations periodically calculated.

3. The control unit according to claim **1**, wherein

the vehicle further comprises a second rotating electric machine mounted on a second power transmission path connected to the output shaft and a second connecting/disconnecting mechanism disposed on the second power transmission path;

the control unit further comprises a controller that controls respective engaging-disengaging states of the first connecting/disconnecting mechanism and the second connecting/disconnecting mechanism; and

the controller uses the axle rotation speed calculated by the second calculator to synchronize rotation of the second connecting/disconnecting mechanism to engage the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is disengaged.

4. The control unit according to claim **2**, wherein

the vehicle further comprises a second rotating electric machine mounted on a second power transmission path connected to the output shaft and a second connecting/disconnecting mechanism disposed on the second power transmission path;

the control unit further comprises a controller that controls respective engaging-disengaging states of the first connecting/disconnecting mechanism and the second connecting/disconnecting mechanism; and

the controller uses the axle rotation speed calculated by the second calculator to synchronize rotation of the second connecting/disconnecting mechanism to engage the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is disengaged.

5. The control unit according to claim **3**, wherein the first power transmission path and the second power transmission path are configured such that a number of transmission stages from the output shaft to the first rotating electric machine is less than a number of transmission stages from the output shaft to the second rotating electric machine.

6. The control unit according to claim **4**, wherein the first power transmission path and the second power transmission path are configured such that a number of transmission stages from the output shaft to the first rotating electric machine is less than a number of transmission stages from the output shaft to the second rotating electric machine.

7. The control unit according to claim **3**, wherein

the vehicle further comprises an engine that is mounted on the vehicle and that causes the second rotating electric machine to generate electric power, and power of the engine is transmitted to the output shaft through the second power transmission path; and

the second connecting/disconnecting mechanism has a function of engaging and disengaging the power through the second power transmission path and a function of switching between a high-gear stage and a low-gear stage.

8. The control unit according to claim 4, wherein

the vehicle further comprises an engine that is mounted on the vehicle and that causes the second rotating electric machine to generate electric power, and power of the engine is transmitted to the output shaft through the second power transmission path; and

the second connecting/disconnecting mechanism has a function of engaging and disengaging the power through the second power transmission path and a function of switching between a high-gear stage and a low-gear stage.

9. The control unit according to claim 3, wherein the controller uses the axle rotation speed calculated by the first calculator to synchronize rotation of the second connecting/disconnecting mechanism to engage the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is engaged.

10. The control unit according to claim 4, wherein the controller uses the axle rotation speed calculated by the first calculator to synchronize rotation of the second connecting/disconnecting mechanism to engage the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is engaged.

11. The control unit according to claim 3, wherein:

the vehicle further comprises a second rotating electric machine speed sensor that detects a rotation speed of the second rotating electric machine as a second rotation speed;

in engaging the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is disengaged, the controller engages the second connecting/disconnecting mechanism after controlling, based on the axle rotation speed calculated by the second calculator and the second rotation speed detected by the second rotating electric machine speed sensor, the second rotating electric machine such that rotation of the second connecting/disconnecting mechanism synchronizes.

12. The control unit according to claim 4, wherein:

the vehicle further comprises a second rotating electric machine speed sensor that detects a rotation speed of the second rotating electric machine as a second rotation speed;

in engaging the second connecting/disconnecting mechanism in a state where the first connecting/disconnecting mechanism is disengaged, the controller engages the second connecting/disconnecting mechanism after controlling, based on the axle rotation speed calculated by the second calculator and the second rotation speed detected by the second rotating electric machine speed sensor, the second rotating electric machine such that rotation of the second connecting/disconnecting mechanism synchronizes.

13. The control unit according to claim 1, wherein

the control unit further comprises a sub-controller that controls an engaging-disengaging state of the first connecting/disconnecting mechanism;

in engaging the first connecting/disconnecting mechanism in a state of being disengaged, the sub-controller engages the first connecting/disconnecting mechanism after controlling, based on the axle rotation speed calculated by the second calculator and the first rotation speed detected by the first rotating electric machine speed sensor, the first rotating electric machine such that rotation of the first connecting/disconnecting mechanism synchronizes.

14. The control unit according to claim 3, wherein:

the vehicle further comprises a second rotating electric machine speed sensor that detects a rotation speed of the second rotating electric machine as a second rotation speed;

each of the first connecting/disconnecting mechanism and the second connecting/disconnecting mechanism is a dog clutch;

the first calculator calculates the axle rotation speed based on the second rotation speed in a state where the second connecting/disconnecting mechanism on the second power transmission path is engaged;

the monitoring unit calculates a second deviation representing a deviation between the axle rotation speed calculated based on the second rotation speed and the wheel speed;

the second calculator calculates the axle rotation speed using the wheel speed and the second deviation in the state where the second connecting/disconnecting mechanism on the second power transmission path is disengaged; and

the controller uses the axle rotation speed calculated from the wheel speed and the second deviation to synchronize rotation of the first connecting/disconnecting mechanism to engage the first connecting/disconnecting mechanism in a state where the second connecting/disconnecting mechanism on the second power transmission path is disengaged.

15. The control unit according to claim 1, further comprising a prohibitor that prohibits, when the deviation is a predetermined value or more, the first connecting/disconnecting mechanism from being disengaged.

16. The control unit according to claim 1, wherein:

the vehicle comprises the first rotating electric machine that drives one of a front wheel and a rear wheel, a third rotating electric machine that drives the other one of the front wheel and the rear wheel without being interposed by a connecting/disconnecting mechanism, and a third rotating electric machine speed sensor that detects a rotation speed of the third rotating electric machine as a third rotation speed; and

when the wheel speed sensor has a failure, the second calculator calculates, based on the third rotation speed, a rotation speed of an axle connected to the one wheel.

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